

# Diversity: A Weapon of Mass Construction

**“No Single Raindrop Believes It Is Responsible For The Flood”**

despair.com

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[http:// ishi.lanl.gov](http://ishi.lanl.gov)



The World's Greatest Science Protecting America

LA-UR-04-7628



## I was asked to “Make it Personal”

- Why am I here today?
- What made me become an advocate for Diversity? Especially since I’m:

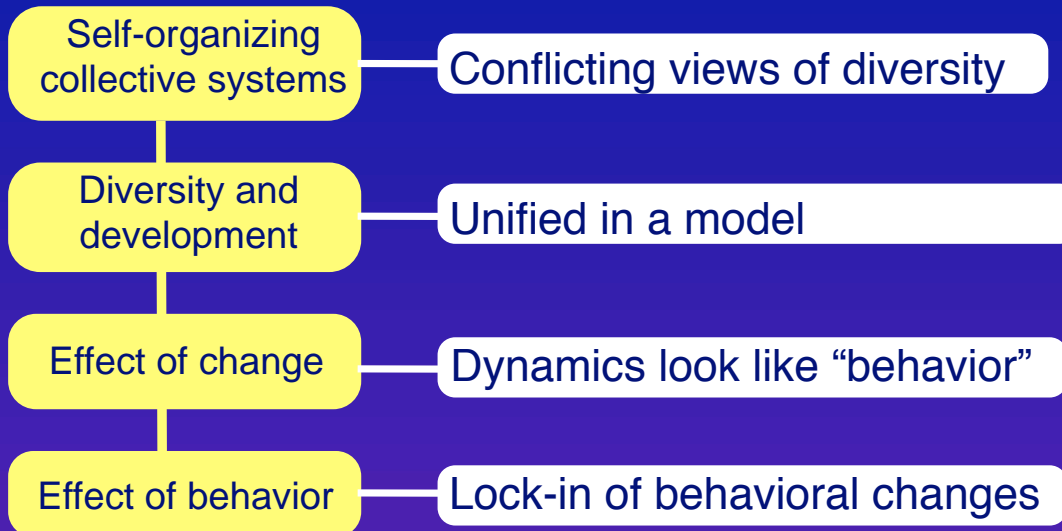
White - Northern European  
Male  
High level security clearance  
Ph.D.  
US born  
Exit-seating capable



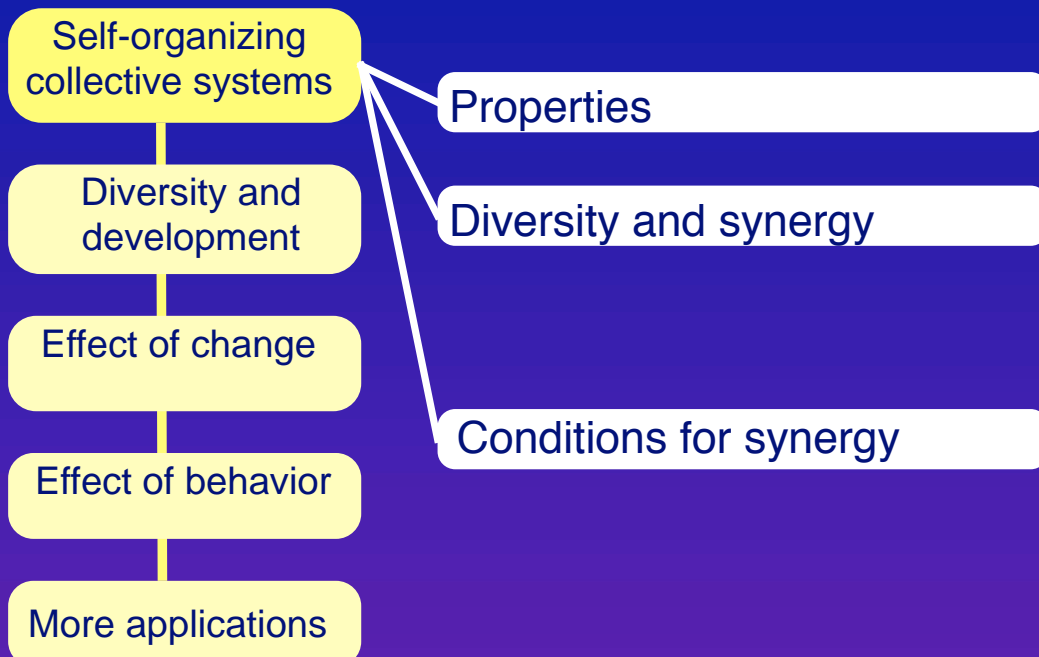
The World's Greatest Science Protecting America



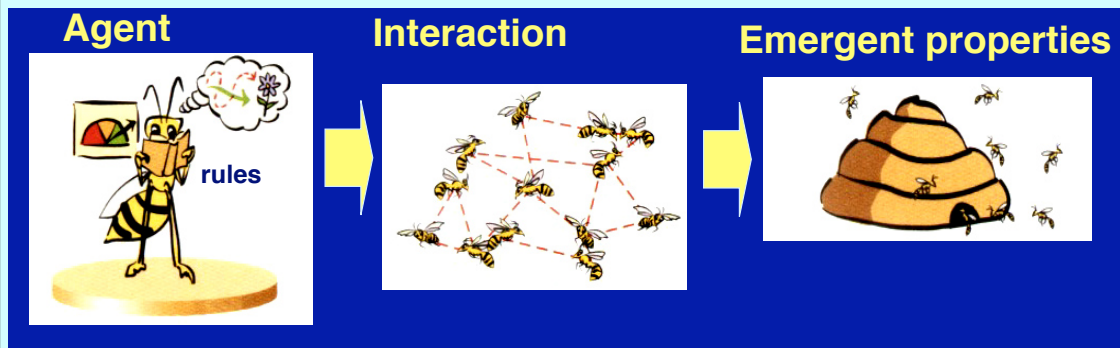
# Roadmap to a Comprehensive View



# Roadmap

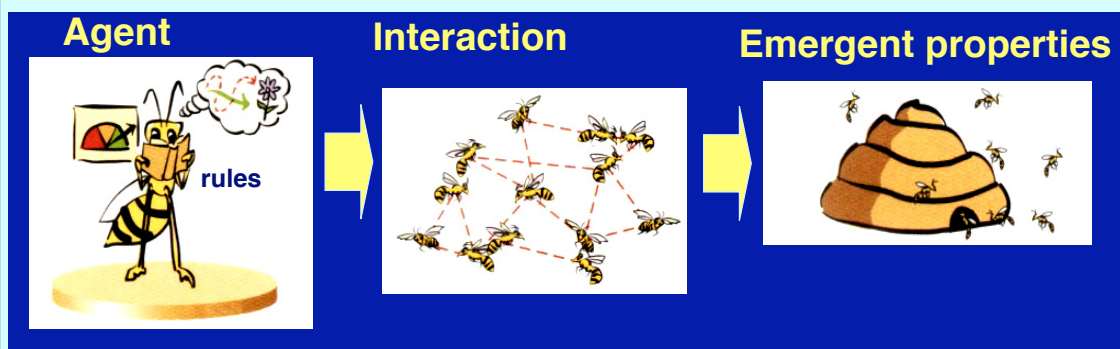


# Self-Organizing Collective Systems



A subset of complex adaptive systems

# Self-Organizing Collective Systems



“Solutions” arise from the dynamics from a diversity of potential solutions.  
*Decentralized, robust, adaptable, fault-tolerant, scalable, ...*

## Fundamental concepts

**Emergent properties**

**Chaotic behavior or non-linear response**

**Structure in chaos**

## Examples of Systems with Emergent Properties

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**Physical systems:** viscosity is a property of a collection of atoms

**The Stock Market:** no expert consistently beats the market as a whole (even including the “bad” investors)

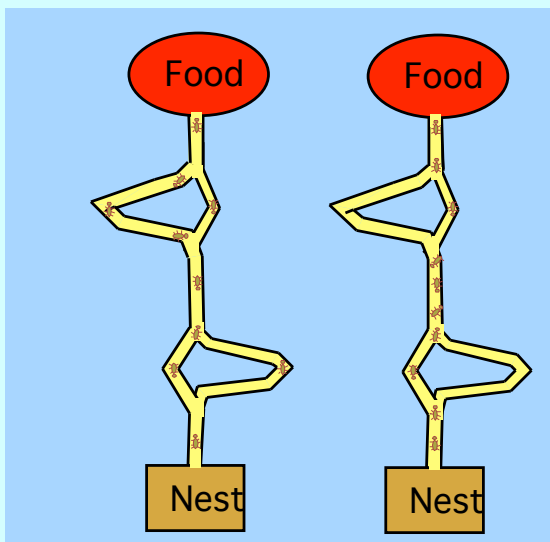
**Social insects**

All of these present significant challenges to an “Expert” trying to describe how these work and to predict their future.

## Ants Solving “HARD” problems

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Most ants foraging for food find the shortest path.

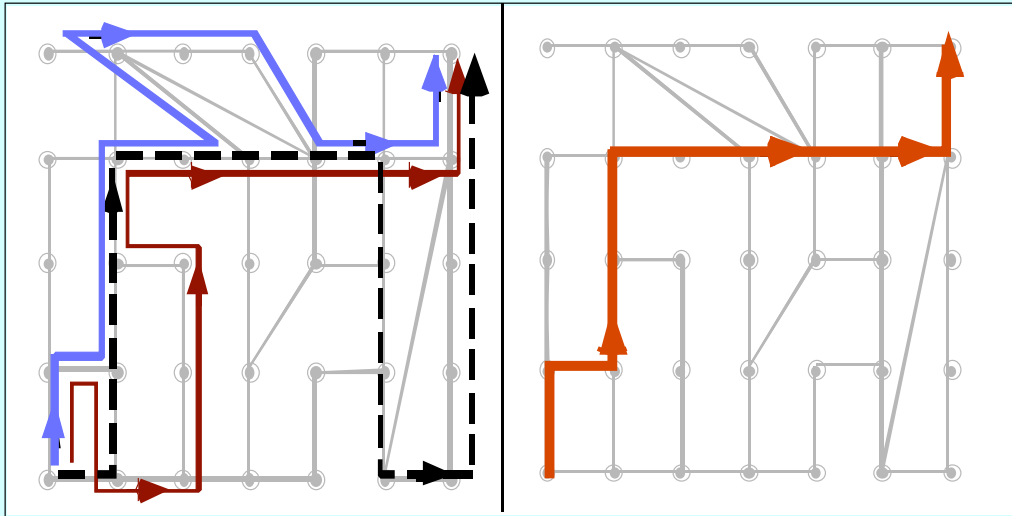


How is this possible?

- No global perspective
- Individual behavior is “dumb” & chaotic.
- No leaders or central coordination

How does it work?

## How ants find the Shortest path



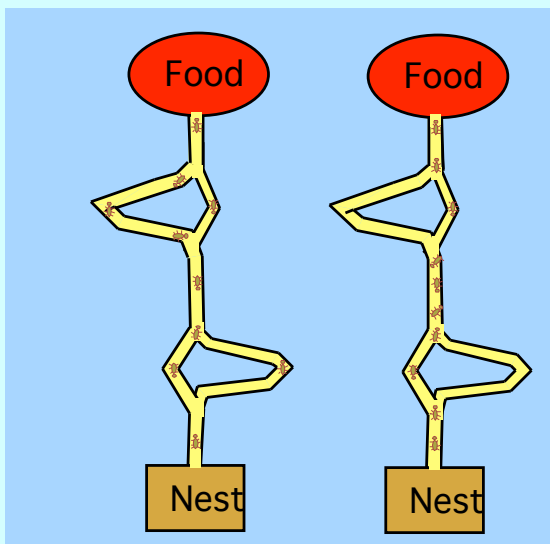
Paths of three ants

Collective path

Diverse pheromone trails (with or without evaporation)

## Ants Solving “HARD” problems

Most ants foraging for food find the shortest path.



How does it work?

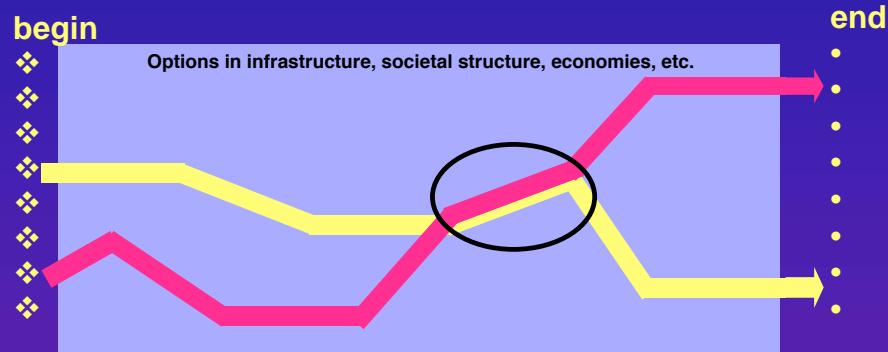
Only works for groups of diverse ants

**Easy to show:** suppose all the ants take the identical path. Then the collective cannot find the shortest path!

# Collectives in complex environments

## In complex domains:

- People's beginning points differ
- Their end points differ
- But local paths can overlay and find synergy



## Diversity - source of conflict or synergy?

### Diversity leads to synergy when collectives have:

- **Common goals**
- **Common identity**
- **Common worldview (agreement on options), but with different preferences or goals**

**Otherwise, diversity can lead to competition and conflict**

# One Business Argument

## **70% of our work knowledge is from informal sources**

Two year, \$1.6 million DOL study of Motorola, Boeing, Ford, etc.

## **\$100-120 billion a year is spent on formal training programs,**

Yet in complex situations, how is the “best training” determined?

## **Why are these informal sources helpful?**

Individual problem solving in a common environment.

Diversity gives unique perspectives.

Individuals contribute to something much greater than they perceive.

## **How do we tap the huge collective resources?**

Investment in enabling Diversity activates informal learning.

Individuals expression, Listen to others, Mixing communities.

# Roadmap

Self-organizing  
collective systems

Diversity and  
development

Effect of change

Effect of behavior

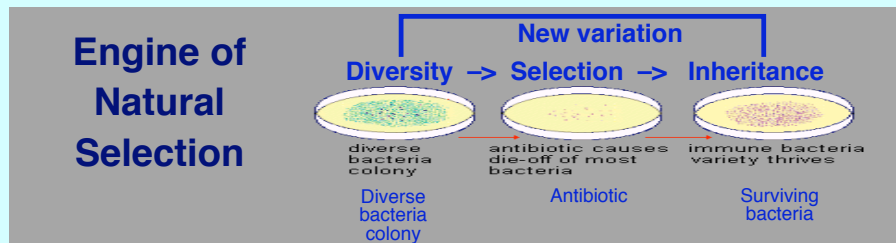
Preconceptions about diversity

Optimization vs. robustness

Developmental stages

Complexity Barrier

# Diversity and Natural Selection



**Higher performance results as a consequence of selection **from** a diverse population.**

**Diversity lowers the global performance:**

*Lower performance of "unfit" individuals  
leads to lower "average" population performance*



## What does the research say?

### Analytical

- Genetic algorithms ("natural selection")
- Iterated Games (Game Theory)
- Ant models

### Empirical

- Harrington at Brown: small investment groups
- Performance in the stock market: Few individuals have outperformed the market as a whole for many years.



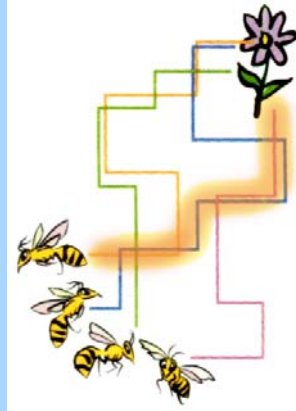
# Two Processes Using Diversity

## Selection



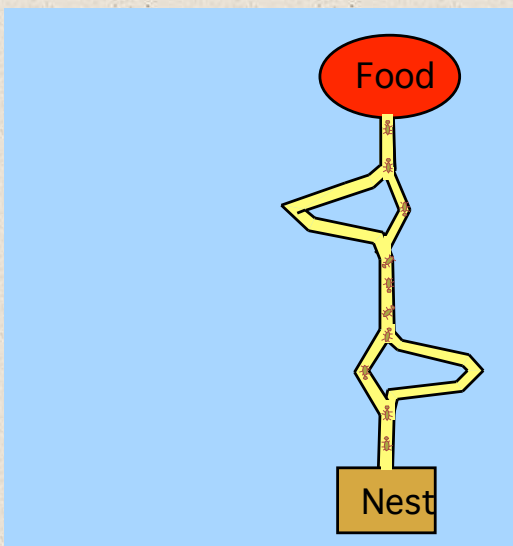
Selection **from** diversity improves the collective

## Synergy



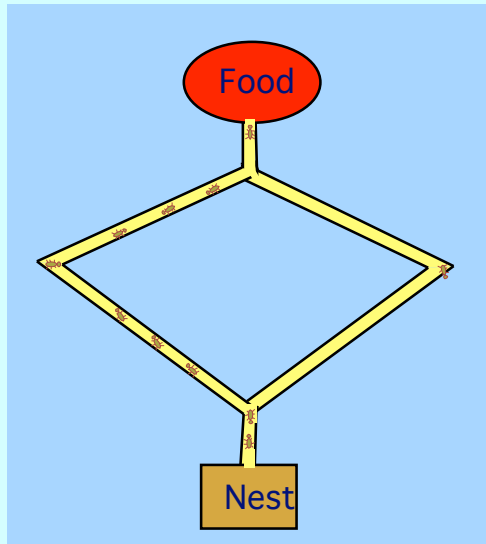
Synergy **of** diverse individual contributions without selection

An “Optimized” collective solution shows high performance , but diversity is restricted



# The Problem with a Condensed Collective

- Ants foraging for food chose one path out of two equidistant paths.



(Deneubourg et al. 1990)

**Cooperation leads to restricted diversity in stable environments**

**Non-linear or Chaotic behavior:**  
Positive reinforcement can amplify random weak signals >> global chaos

**Social insects planned for this...**

## Three Mechanisms for Collective Performance

### Selection



Selection **from** diversity improves the collective

### Synergy



Synergy **of** diverse individual contributions without selection

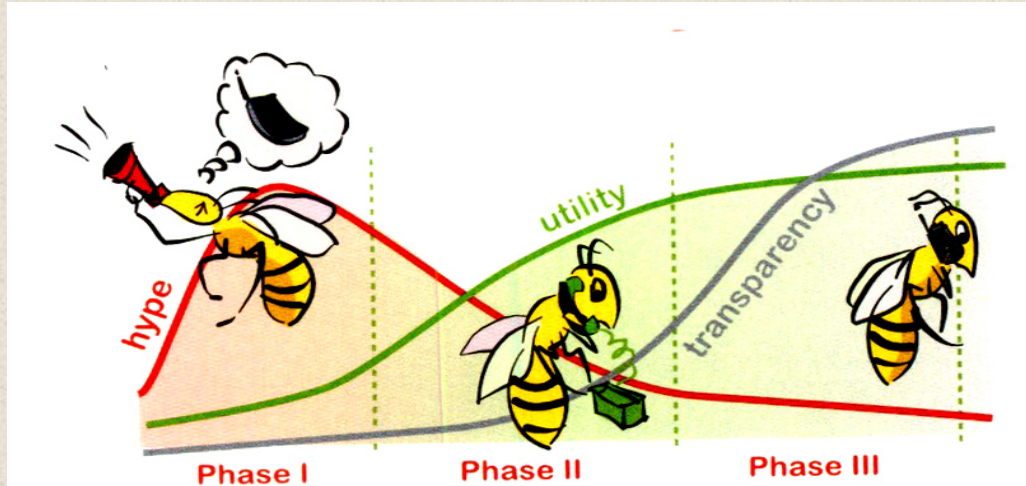
### Optimization



Efficient, but little flexibility

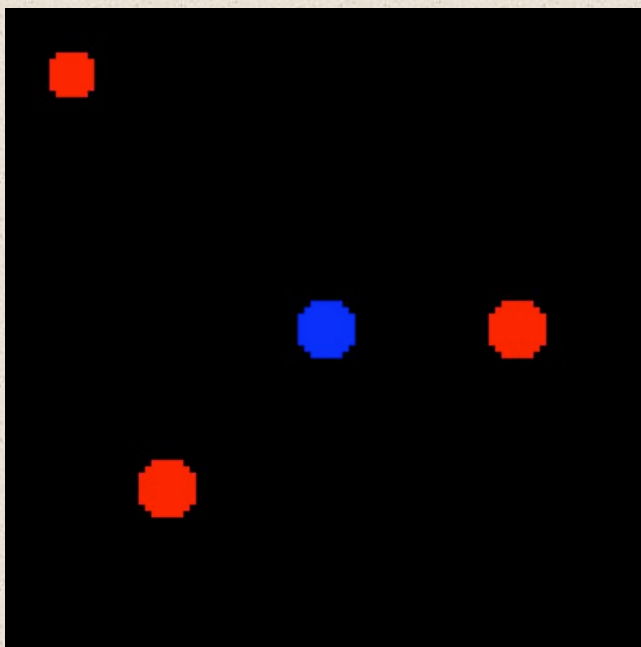
Almost everything has cycles or stages of development

## Developmental Stages of Consumer Technology



And you act differently & system has different dynamics at different stages

## Simple Ant Consumer Model



### Collective information

- Evaporation
- Diffusion

### Agent internal state:

- Current direction
- Have food?

### Three rules of action:

- Carry food
- Drop food
- Search

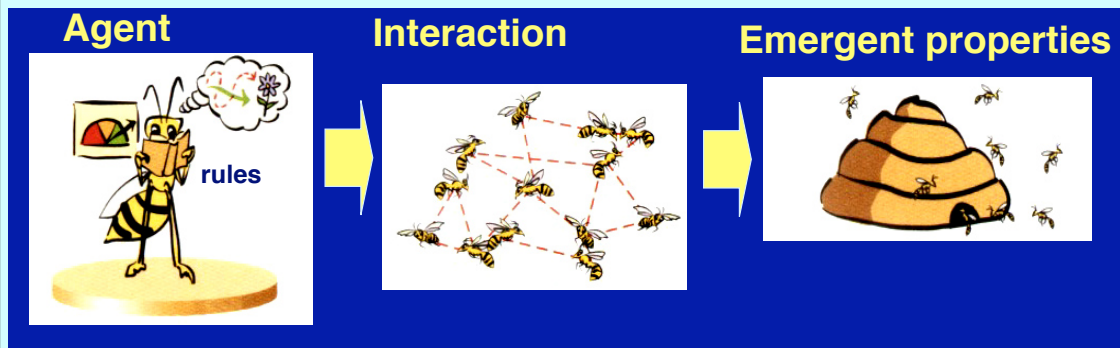
■ Productive collective

■ "Salaried men"

■ Individual/Innovator

■ Collective structure

# Self-Organizing Collective Systems



## Fundamental concepts

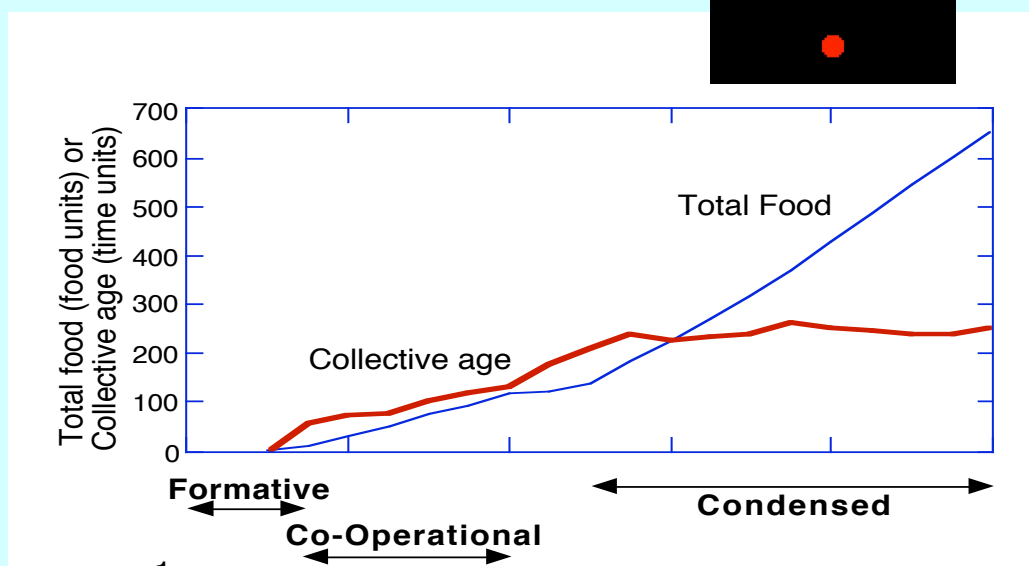
**Emergent properties - Closest food, Shortest path**

Chaotic behavior or non-linear response

Structure in chaos

## Three stages for a stable environment

Total Production versus time



# Stages of Collective Development

**Formative**  
Form individual definition



**Co-Operational**  
Improvement by collective



**Condensed**  
System optimization



**Now we can connect the three observations as three stages in one system**

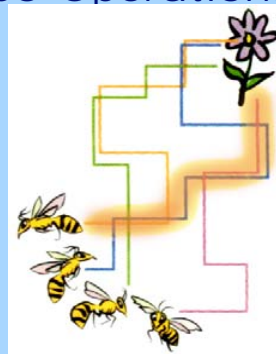
# Stages of Development

**Formative**



- Locally chaotic (agent's path)
- Globally chaotic (productivity)
- Robust global performance
- Production by "innovative" agents
- High diversity**

**Co-Operational**



- Locally chaotic
- Globally predictable
- Robust global performance
- Production by both classes
- High diversity**

**Condensed**



- Locally predictable
- Globally predictable
- Fragile
- Production by collective
- Low diversity**

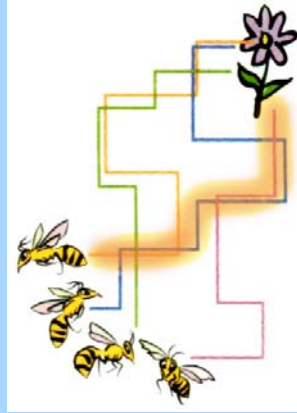


# Why not optimize directly?

Formative  
Forming definition



Co-Operational  
Improvement by collective



Condensed  
System optimization



**X**  
Complexity Barrier

## What is an Expert in your Area?

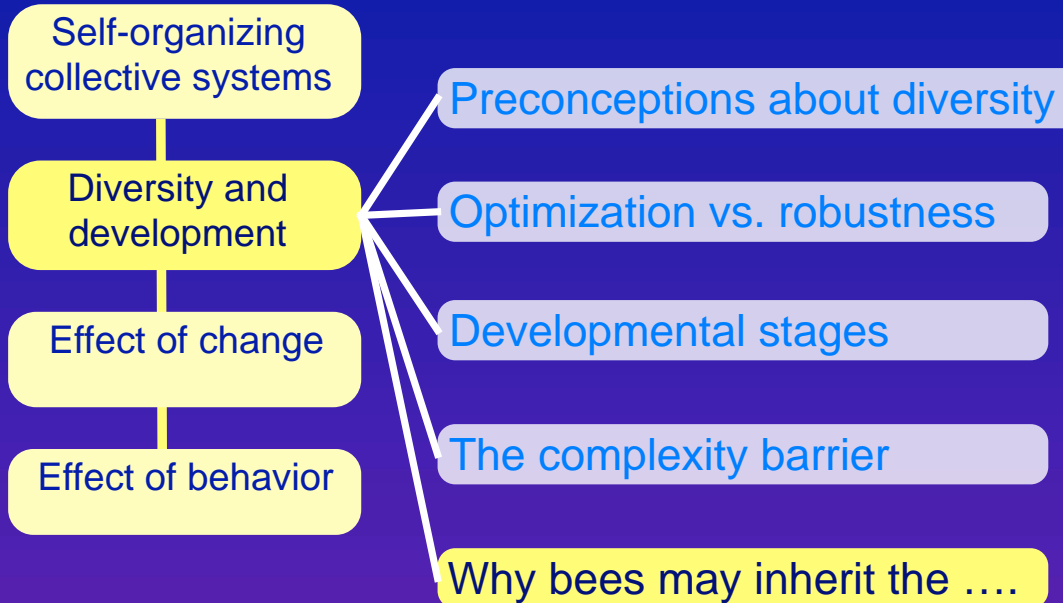
- 1. Someone that tells you the rules to make good decisions.
- 
- 2. Someone that gives you good decisions, but the rules claimed for his decisions aren't useful
- 
- 3. There are no experts.

# What is an Expert?

*Someone that tells you rules or decisions?*

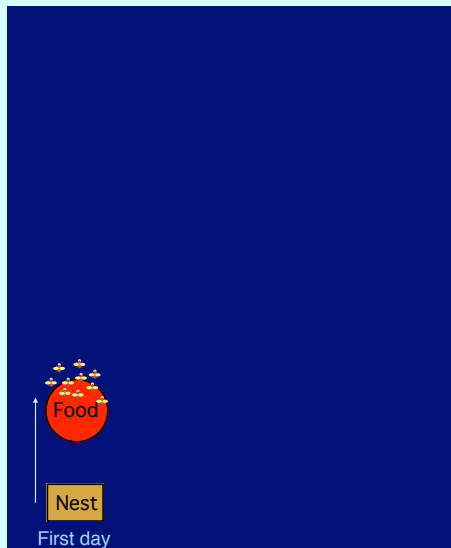
- 
- *“Expert” systems only work if the expert cognitively understands the system.*
- 
- *In complex systems, experts are intuitive and can give good decisions without knowing why*
- 
- *In highly complex situations, there are no experts and “Co-Operational” approaches are the best way to predict and respond to the future*

## Roadmap

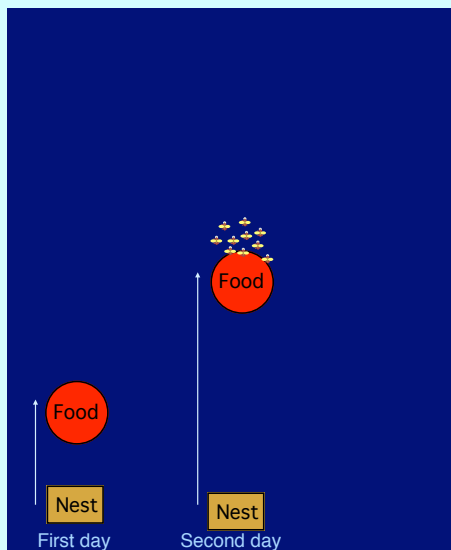


## Researching Bee Talk

Don't underestimate collectives



## Researching Bee Talk





# Researching Bee Talk

Where is the prediction taking place?

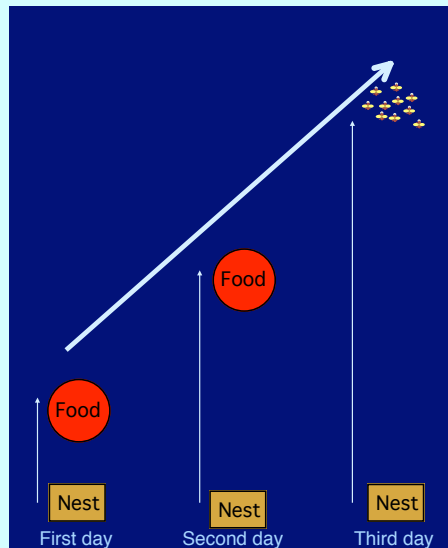
Where is memory located?

Bee memory - 1 week  
Bee life - 6 week.  
Hive memory - 12 weeks.

Why are social insects so disturbing?

All hive functions are emergent properties

Why aren't we as impressed with human collectives?



# Roadmap

Self-organizing  
collective systems

Diversity and  
development

Effect of change

Effect of behavior

# The Impact of Change on Ourselves

- Are you busier this year than last?
- Are you using more information sources than you did last year?
- Do you know more people than ever before? (but less quality ones?)
- Are you more uncertain about the future?
- Things that you thought would never change - are changing?

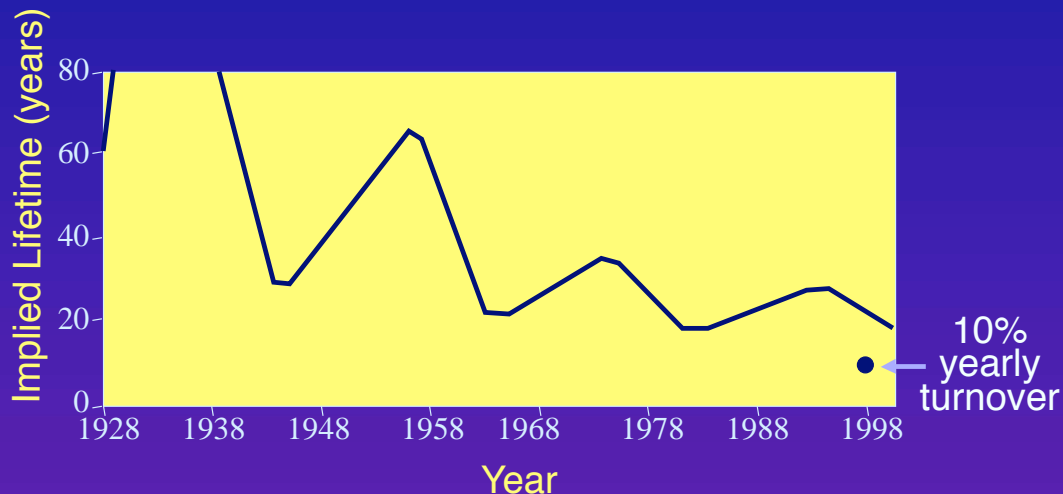


## Why worry about change?

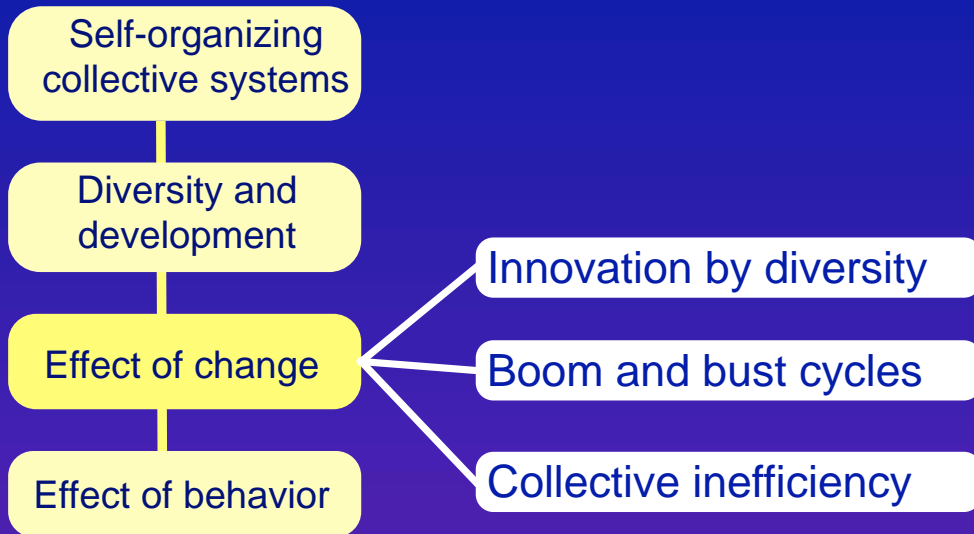
- Average Lifetime of S&P 500 Companies

From *Creative Destruction*

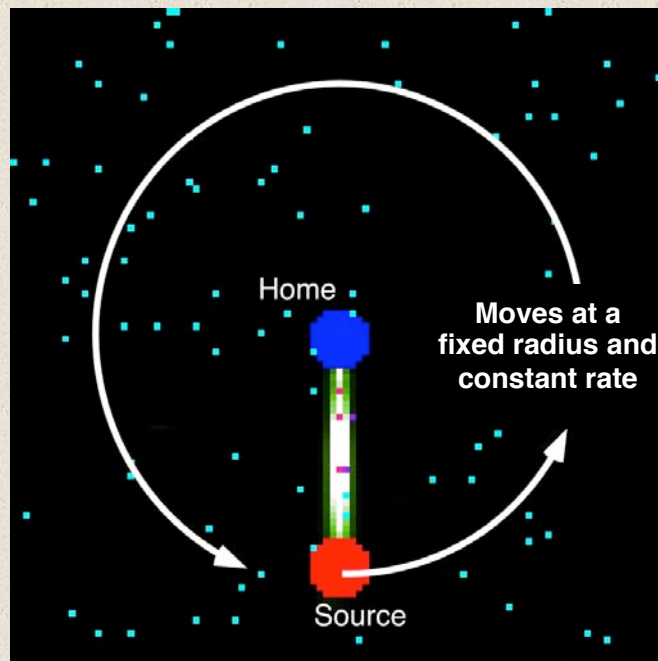
by R. Foster and S. Kaplan



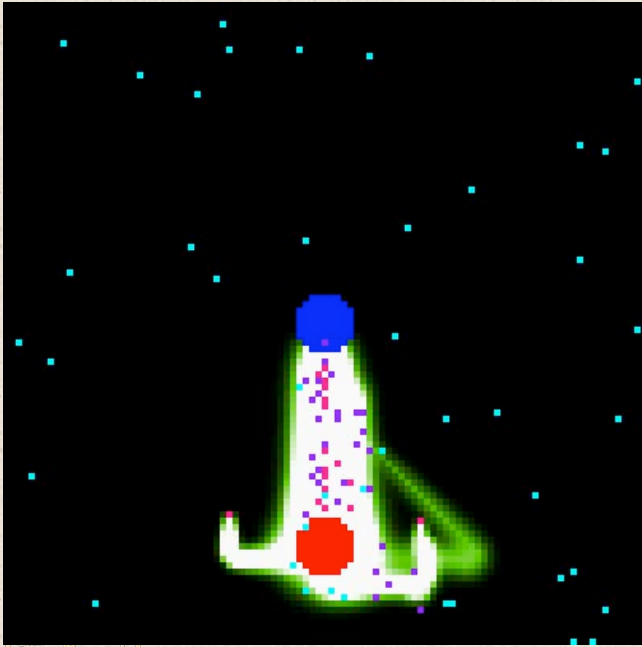
# Roadmap



## Collectives in a dynamics environment



## Slowly changing environment



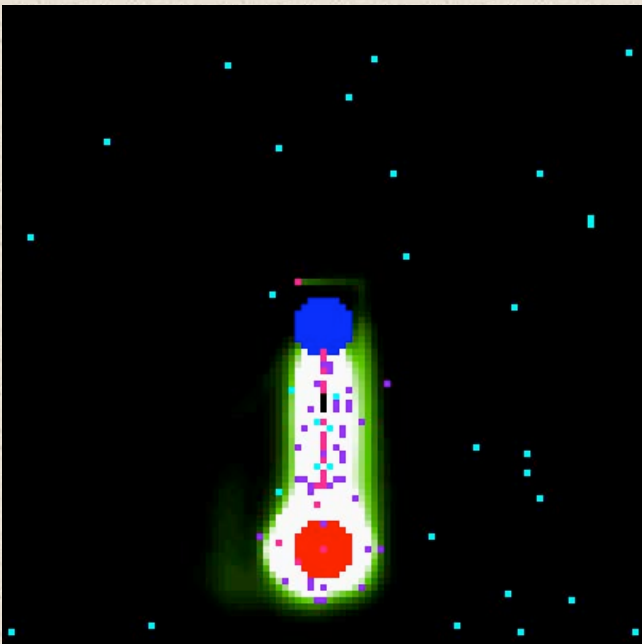
Productivity is only slightly less than an unchanging source

Herd effect allows for quick utilization of new resource location

Innovators become important (again) by sustaining optimal performance of the collective



## Same but Faster by 1/3



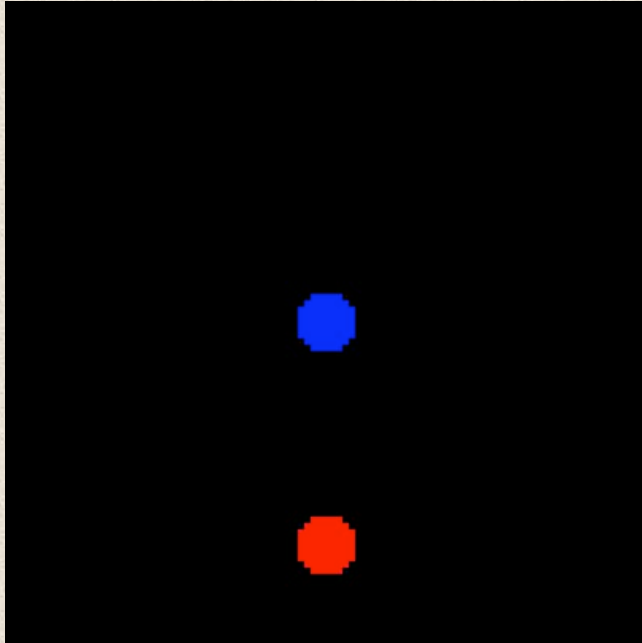
Boom and bust cycle

Instabilities lead to reversion to prior developmental stages

Equal importance of herd effect and innovators



## Rapidly changing in environment



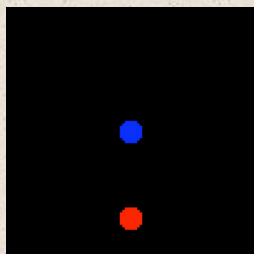
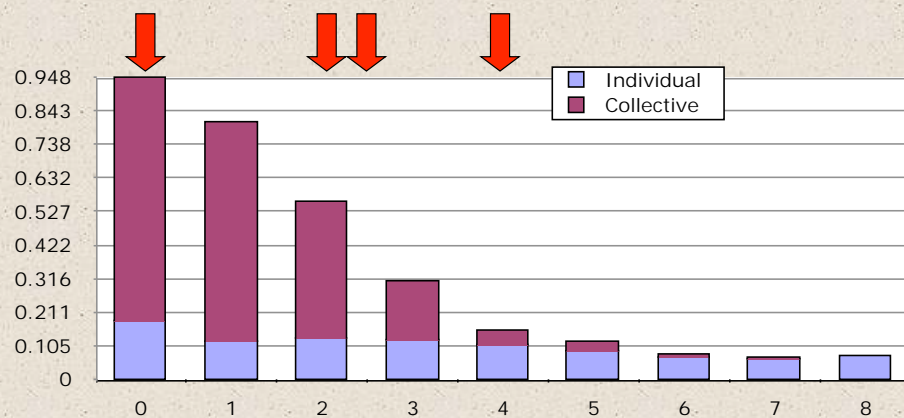
Almost all productivity is from innovators

The highly productive Optimized stage is never realized

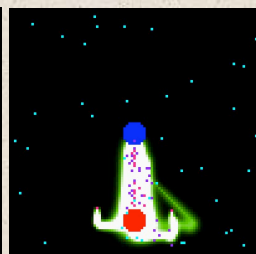
The herd effect actually degrades the performance by tying up resources



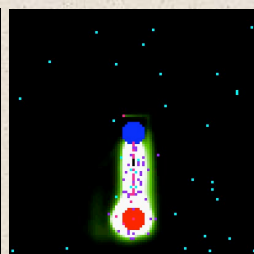
## Food Production Rate vs. Rotation Rate



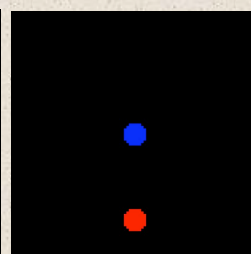
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2



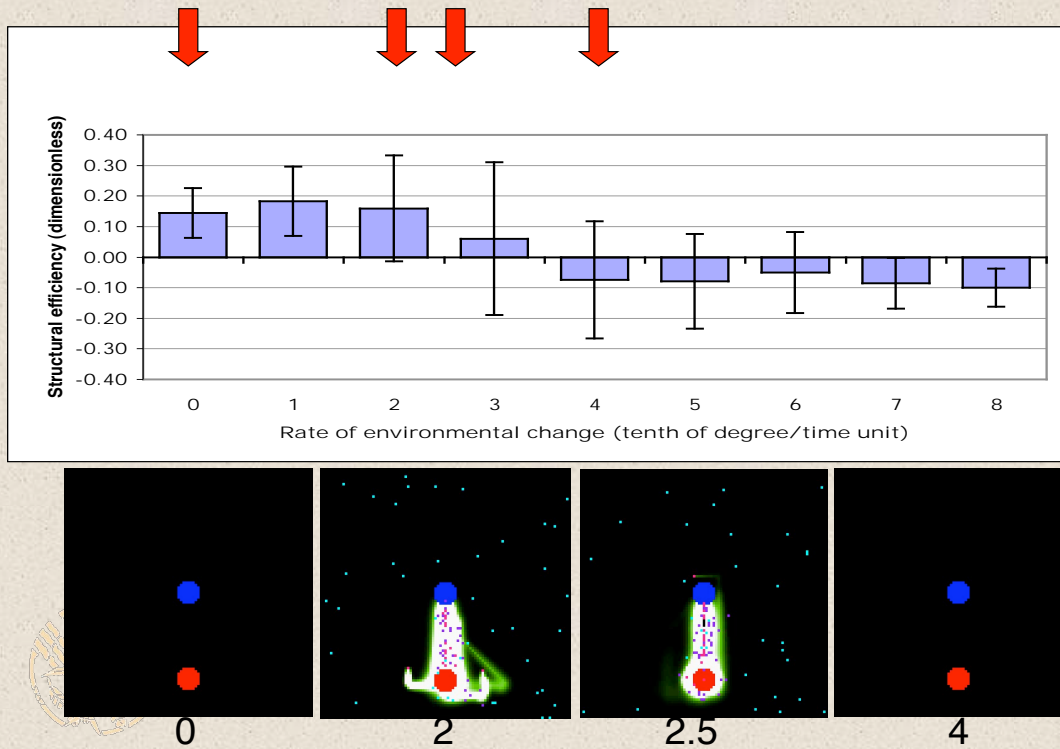
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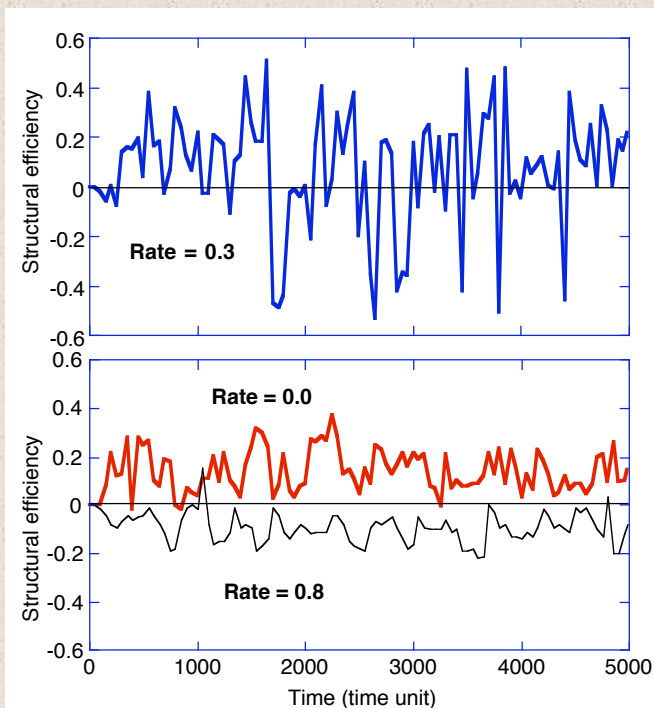
4



## Structural Efficiency (Collective efficacy)



## Structural Efficiency - Boom and Bust



**Lower average production --> need crash avoidance**

**Manic: Greater minimums and maximum when compared to extreme rates!**

**Bust is preceded by increased production**

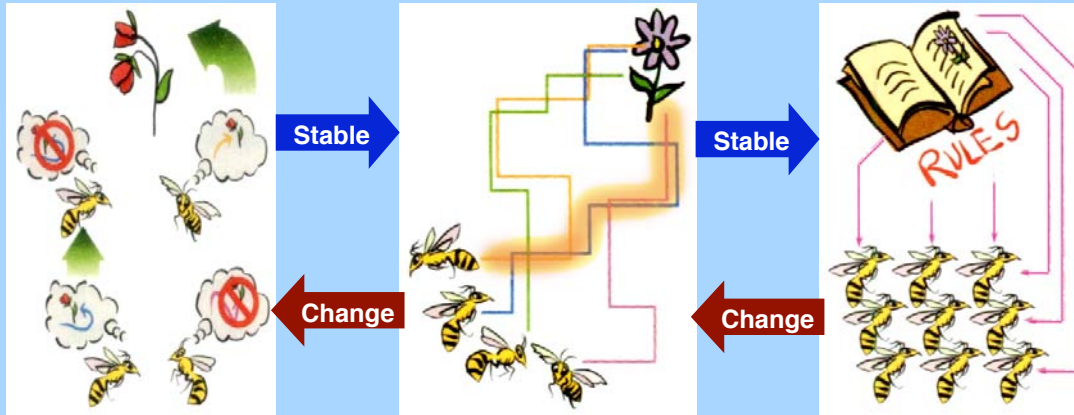


# Collective Response to Rates of Change

Formative

Co-Operational

Condensed



**Rate of Change determines the final state**

## Sustainable strategies in fast changing times

### Enable, manage and sustain diversity

- Diverse groups = diverse information
- Diverse groups best at recognizing the herd in action
- Diverse groups optimal for vetting and amplifying innovation
- Socialize “world views” and common understanding

### Activate self-organizing processes

- Keep strategic plans simple (Eisenhardt)
- Focus on process, not products (process continually reinvents)

### Improve your response to herd (herd) behavior

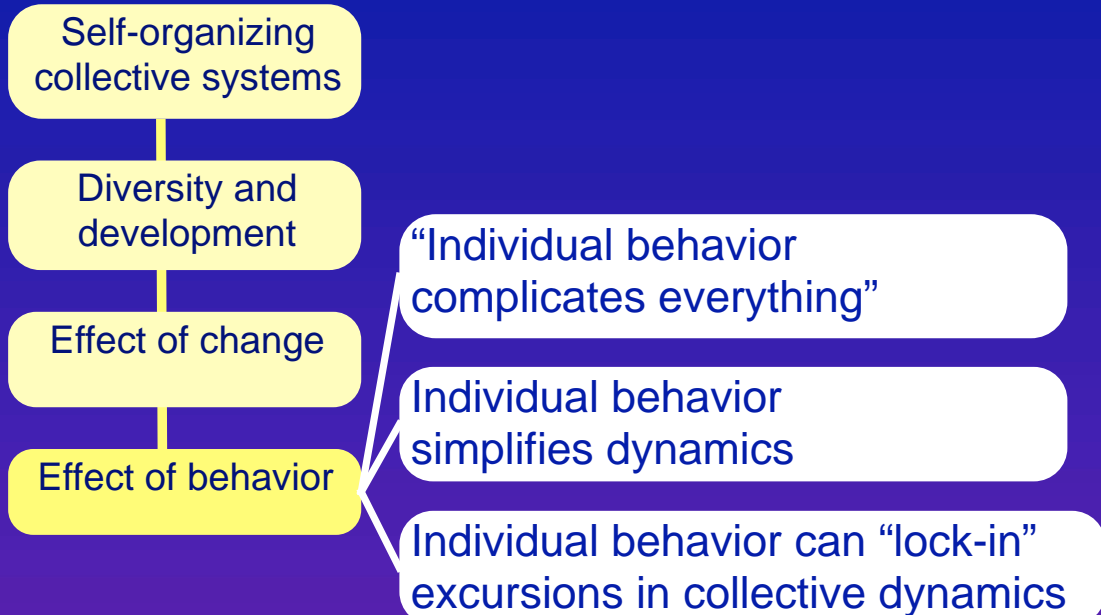
- Recognize herding by loss of diversity and reduced social network
- The herd solution will not be robust or optimal

### Consider universal ethics vs. local community ethics



**“Typical engineer ... He never talked about emotions”**

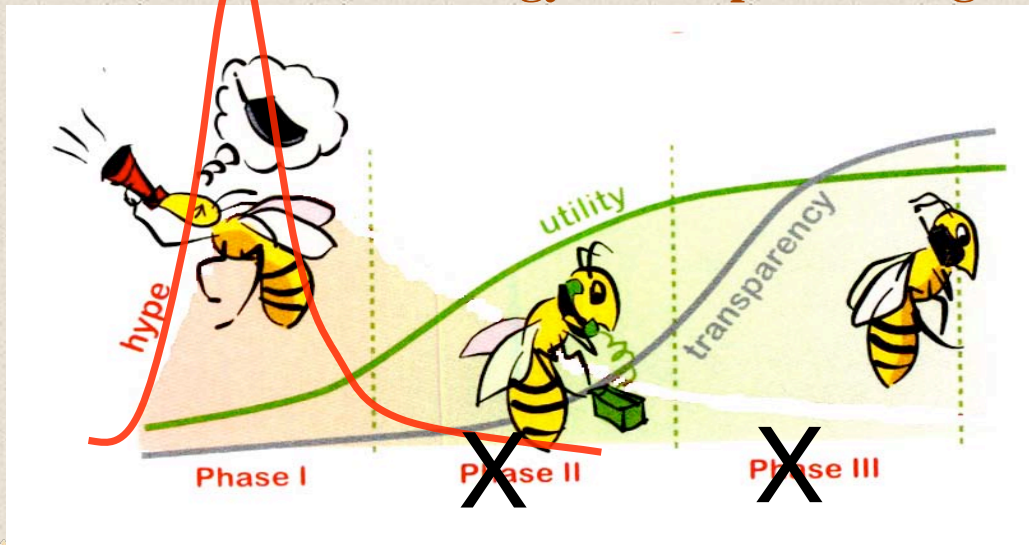
## Roadmap





## What about individual & collective behavior?

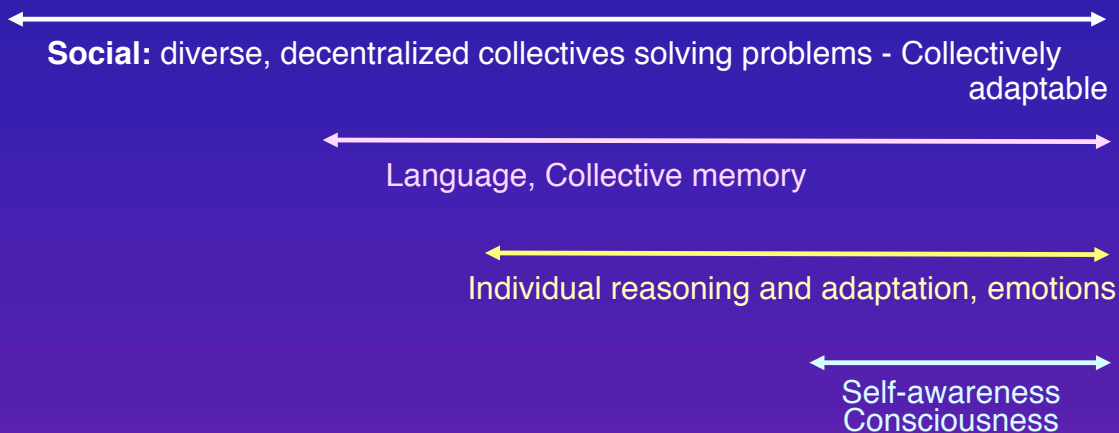
### Technology Development Stages



- ❖ Collective reinforcement of unsatisfied expectations can lead to an interruption of the developmental cycle

## What does it mean to be “social”?

slime molds	“low” social insects	“high” social insects	social mammals	“low” apes	“high” apes	humans
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## What are the effects of stress and unmet needs?

### **STRESS:**

Stress reduces the expression of one's diversity

Stress increases "group think" (e.g., post 9/11)

Sustained stress can lead to habitual repression

### **NEEDS:**

Unmet needs makes one more rational

### **NEEDS and STRESS:**

Sustained stress and unmet needs leads to creative and skillful ways to get one's needs satisfied

(e.g., Alice Miller, "Drama of a Gifted Child")



## Test Questions

- Have a drink, kill the weak brain cells and get smarter
- 
- Diversity on an assembly line?
- 
- Do you have a bumper sticker: "I brake for synchronicity"?
- 
- What is your identity? Where do you store the catsup?
- 
- The Complexity Barrier also applies to discrimination
- 
- How to build a Democracy?

## Are **WMC** like **WMD**? Which are not?

- Their use has significant consequences
- They are coveted by all
- They only can be created in mature societies
- Are reusable
- Those that have them, don't want others to have them
- Once they are out of the box, you can't put them back in
- They are selectively used by the powerful to justify their actions
- They require continual attention to keep them working

## Diversity and Fast Changing times

**"Problems cannot be solved at the same level of awareness that created them."** *Albert Einstein*

Self-organizing  
collective systems

More widespread and important than  
commonly appreciated

Diversity and  
development

Diversity can lead to instability or  
better solutions, depending on  
complexity & identity

Effect of change

Innovation (diversity) is essential  
in coping with change

Effect of behavior

Our adaptations may not be optimal in  
dealing with change

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